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THE PYROLYTIC EFFECT OF TREATING COTTONWOOD WITH PLANT ASH[1]

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ABSTRACT

Cottonwood and cottonwood cellulose were treated with plant ash produced by ignition. The treatments caused changes in thermal behavior and pyrolysis products. However, the effect was not as pronounced as that resulting from naturally contained levels of minerals. This may mean that isolation of minerals by ignition produces changes which render the treatment less effective.

Recent research on the pyrolysis of cellulose contaminated with inorganic compounds has led to speculation that the flammability of plant materials could be influenced by their inorganic constituents.[3] [4] Further evidence supporting this possibility was reported by King and Vines who found the burning characteristics of dry, extractive-free leaves to be directly related to their mineral content.[5] The thermal properties of several plant materials determined by differential thermal analysis (DTA) and thermogravimetric analysis (TGA) were found to be correlated with their silica-free mineral content.[6] This suggests a variable to be altered or considered when developing fire resistant plants, rating natural fuels, and assessing the seasonal changes in flammability.

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[1] The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

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[3] A. Broido and M. Nelson. Ash content: its effects on combustion of corn plants. Sci. 146: 3644, 3652-3653. 1964.

[4] Y. Waisel and J. Friedman. The use of tamarisk trees for the restriction of fires. La-Yaaran 15(3): 77-82 (Hebrew); 84-88 (English). 1965.

[5] N. King and R. Vines. Variation in the flammability of the leaves of some Australian forest species. Div. Appl. Chem., CSIRO, Australia, 14 p. 1969.

[6] C. Philpot. Influence of mineral content on the pyrolysis of plant materials. Forest Sci. 16(4): 461-471, illus. 1970.

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Since the majority of past work has dealt with natural fuels of varying mineral contents, we tried the inverse experiment by using artificially applied minerals. The resulting report presents some preliminary results from the pyrolysis of cottonwood *(Populus trichocarpa)* and cottonwood cellulose. Cottonwood samples were treated with 5 percent by weight of cottonwood ash and also with 5 percent by weight ponderosa pine *(Pinus ponderosa)* ash. Cottonwood cellulose samples were also given these two treatments. This initial work was done in conjunction with a larger study previously reported.[7] A complete description of the equipment, techniques, and methods was presented at that time.

EXPERIMENTAL PROCEDURES

Samples of cottonwood and cellulose isolated from cottonwood were given the two treatments of 5 percent cottonwood ash (CWA) and 5 percent ponderosa pine ash (PPA) by weight. The ash was obtained from cottonwood wood and ponderosa pine needles, using standard ignition methods at 600° C.[8] The ponderosa pine needle ash was used for convenience. A partial elemental analysis of both ashes and the amount of each element added by a 5 percent treatment is shown in table 1. The treated samples were analyzed by thermal analysis and pyrolysis gas chromatography. The untreated cottonwood cellulose contained <0.1 percent mineral content.

Differential thermal analysis (DTA) was performed by using 10 mg. of sample on a DuPont Model 700-750 thermal analyzer. The heating rate was 15°/minute and the atmosphere was nitrogen flushing at 100 cc./minute. Thermogravimetric analysis (TGA) was run on 10 mg. of sample at the same heating rate and atmospheric conditions. The pyrolysis temperature for gas analysis was 600° C. A Hewlett-Packard FM Model 5750 chromatograph was used with dual 14-foot stainless steel columns packed with 10 percent carbowax M on Fluropak 80. Standard identification procedures of each product were performed as previously reported.[9] The char is the residue remaining after 20 minutes in the pyrolysis chamber that is connected to the chromatograph.

Table 1.--*Partial elemental analysis of plant ash*

Ash type	SiO_2	Element				
		P	K	Ca	Fe	Na
				Percent		
Cottonwood	0.00	3.30	17.57	15.94	0.20	0.16
5 percent cottonwood ash	.00	.16	.88	.79	.01	.00
Ponderosa pine	59.95	1.80	5.68	12.92	.52	.00
5 percent ponderosa pine ash	3.00	.09	.28	.65	.03	.00

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[7] C. W. Philpot. The pyrolysis products and thermal characteristics of western cottonwood and its components. USDA Forest Serv., Intermountain Forest and Range Exp. Sta., Ogden, Utah (Manuscript in preparation.)

[8] American Society for Testing and Materials. Method of test of ash in wood. D1102-56, Philadelphia, Pa. 1956.

[9] See footnote 7.

RESULTS

Preliminary results show a definite effect of the two kinds of ashes on the pyrolytic behavior of cottonwood and cottonwood cellulose. Figure 1 shows the DTA of cellulose resulting from the two ash treatments. Although both ashes lowered the initiation temperature of the cellulose and decreased the intensity of the endotherm, the most effective ash seems to be cottonwood. The initiation temperature is the temperature where pyrolysis begins. Figure 2 shows the TGA of cellulose with both treatments. The pyrolysis rate was decreased and the char increased by both treatments with cottonwood ash being the most effective.

Some of the pyrolysis products from cottonwood and its treatments are shown in table 2. Generally there was a slight increase in water and CO_2 products from the treated samples and the char also increased. There was also an increase in fixed gases; a decrease in acrolein, acetic acid, and acetaldehyde was apparent.

Some of the products from cottonwood cellulose and its treatments are listed in table 3. Fixed gases, CO_2, H_2O, char, 1-hydroxy-2-propanone, acetic acid, and 2-furaldehyde all increased. There was a decrease in furan and 2,3-butanedione.

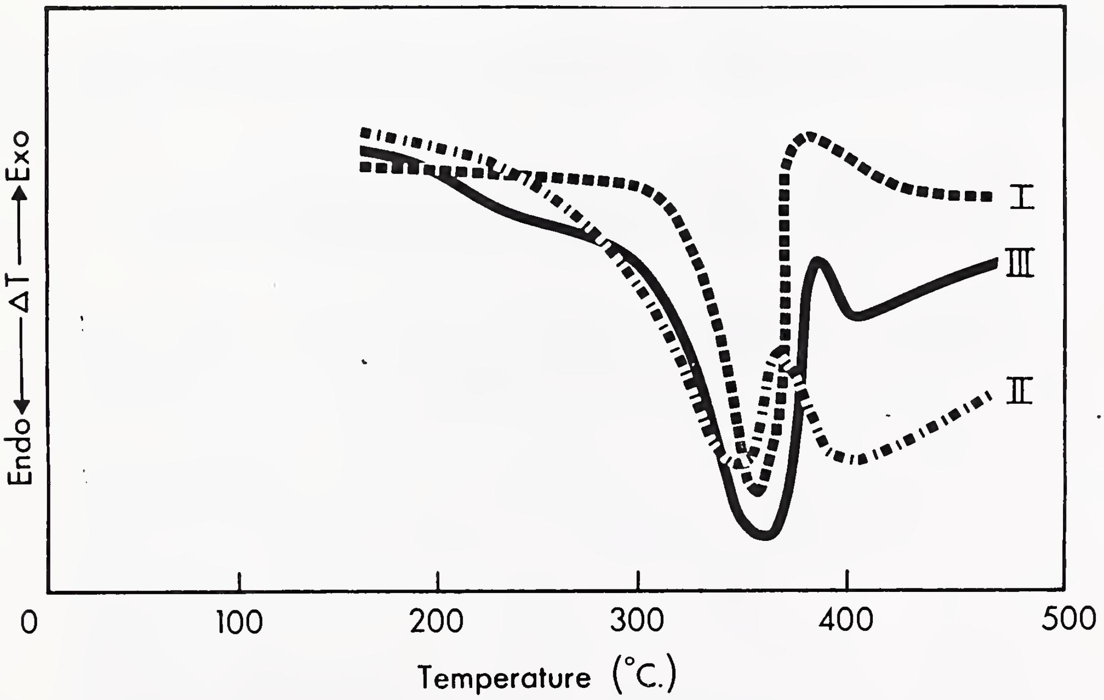

Figure 1.--Differential thermal analysis of cottonwood cellulose (I); cottonwood cellulose plus 5 percent cottonwood ash (II); and cottonwood cellulose plus 5 percent ponderosa pine ash (III).

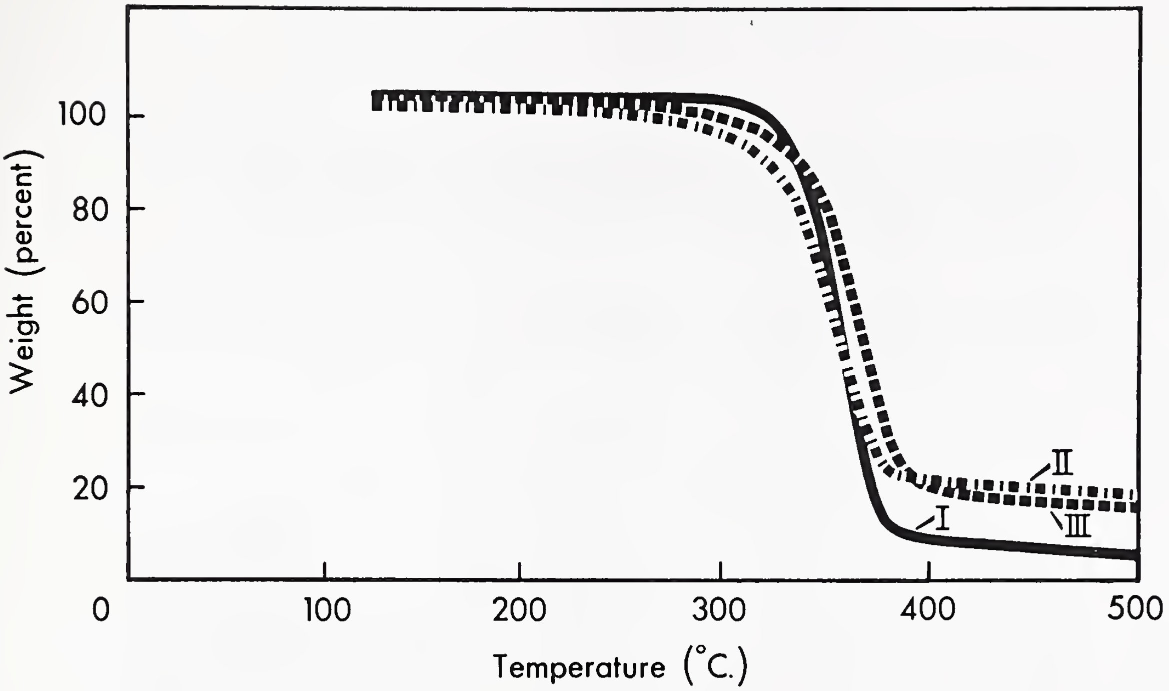

Figure 2.--Thermogravimetric analysis of cottonwood cellulose (I); cottonwood cellulose plus 5 percent cottonwood ash (II); and cottonwood cellulose plus 5 percent ponderosa pine ash (III).

Table 2.--*Some pyrolysis products from untreated cottonwood and cottonwood treated with 5 percent ponderosa pine ash (PPA) and 5 percent cottonwood ash (CWA)*

Product	Cottonwood		
	Untreated	PPA	CWA
	- - - - - - - - - *Counts/mg.* - - - - - - - - -		
Fixed gases	21,900	23,400	23,500
	- - - - - - *Percent (dry weight)* - - - - -		
Acetaldehyde	2.3	1.6	1.7
Furan	1.6	1.0	1.7
Acrolein	3.2	1.4	1.1
2,3-Butanedione	2.0	1.3	1.2
1-hydroxy-2-propanone	2.1	2.7	2.3
Glyoxal	2.2	2.1	2.9
Acetic acid	6.7	5.2	4.6
2-Furaldehyde	1.1	1.8	1.1
CO_2	12.0	13.0	14.0
H_2O	18.0	19.0	19.0
Char	15.0	19.0	19.0

Table 3.--*The volatile products and char from untreated cottonwood cellulose and cottonwood cellulose treated with 5 percent ponderosa pine ash (PPA) and 5 percent cottonwood ash (CWA)*

Product	Cellulose		
	Untreated	PPA	CWA
	Counts/mg.		
Fixed gases	12,900	17,000	18,600
	Percent (dry weight)		
Acetaldehyde	1.3	1.1	1.5
Furan	1.4	.7	.6
Acrolein	1.5	1.4	1.0
2,3-Butanedione	1.4	.6	.6
1-Hydroxy-2-propanone	1.9	2.7	3.2
Glyoxal	2.0	2.0	3.1
Acetic acid	.8	2.0	2.8
2-Duraldehyde	.9	1.7	2.0
CO_2	6.0	9.0	11.0
H_2O	11.0	15.0	15.0
Char	5.0	13.0	13.0

CONCLUSIONS

Ash from cottonwood and ponderosa pine needles changed the pyrolysis characteristics of cottonwood and also changed the products obtained from cottonwood and cottonwood cellulose. The thermal analysis of treated cellulose showed typical changes due to contamination; cottonwood ash was most effective. The effects of treatments were not as pronounced as was observed for equal levels of naturally-held plant inorganics.[10] Although the treatments produced changes in pyrolysis products, they are generally not too pronounced. It is also interesting that such changes did not seem to correspond to those previously produced by acid or alkali model contaminants.[11]

The major problem of this study was probably the method of isolating the inorganics. Drastic changes may have occurred that rendered the treatment less effective than natural contaminants. Before this work is continued, the forms in which minerals exist in plant tissue must be considered. This will enable the treatments to more closely represent natural plant inorganics.

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[10] See footnote 6.

[11] See footnote 7.